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LAUNCH SITE
NAL CONCEPTS
SORTIE MISSIONS

AS10-8043 MARCH 1973

pared for

Y SPACE CENTER, NASA
E CENTER, FLORIDA

EXECUTIVE SUMMARY

SHUTTLE LAUNCH SITE OPERATIONAL CONCEPTS FOR CERTAIN SORTIE MISSIONS

NAS10-8043 MARCH 1973

Prepared for

JOHN F. KENNEDY SPACE CENTER, NASA
KENNEDY SPACE CENTER, FLORIDA

APPROVALS:

V. A. Dulock, Jr.
Study Manager
TRW Systems Group

R. L. Norman
NASA Technical Monitor
Kennedy Space Center

FOREWORD

The Shuttle Launch Site Operational Concepts for Certain Sortie Missions study was conducted by TRW Systems Group for the John F. Kennedy Space Center, Kennedy Space Center, Florida. The study was conducted from July 1972 through March 1973 under Contract NAS10-8043.

This document presents an executive summary of the study work and is submitted in accordance with the requirements delineated in Section 7.0 of the contract statement of work. The Study Report consists of the following:

Volume I - Detailed Technical Report, October 1972
Volume II - Detailed Technical Report, December 1972
Volume III - Detailed Technical Report, March 1973
Appendix, March 1973
Executive Summary, March 1973

The TRW study team operated under the technical direction of a KSC Study Technical Management Team chaired by Mr. R. L. Norman. The membership of the Technical Management Team is:

KSC/LL-MLV-A/R. L. Norman (Chairman and Technical Monitor)
KSC/LS-ENG-51/J. D. Ream
KSC/IN-DAT/D. Clark
KSC/SP-PAY/D. Bailey
KSC/LV-GDC-4/B. Haynes
KSC/SO-LAB-3/C. W. Hoppesch
KSC/DD-SED-4/R. Lupo
KSC/SP-PAY/R. Engel
KSC/LL/J. W. Johnson
KSC/LV-CAP/R. C. Prince
KSC/AA-SVO-1/N. R. Wirman
MSC/ER-4/E. Crum

In addition to the Technical Management Team, the TRW study team received agency-wide guidance and overview by a NASA Steering Committee to assure optimum technical and program continuity and to maximize objectivity in concept development. The membership of the NASA Steering Committee is:

KSC/SP-PAY/H. E. McCoy (Chairman)
Hqtrs/MTL/W. O. Armstrong
Hqtrs/MFI/B. G. Noblitt
Hqtrs/RFE/D. Novik
Hqtrs/MLS/J. D. Lundholm
Hqtrs/SF/R. G. Wilson
Hqtrs/MHL/W. E. Moore
Hqtrs/PA/W. A. Flemming
GSFC/110/W. G. Stroud
MSFC/PD-AP/R. Crawford
MSC/ER/R. Berglund
ARC/SS/M. Bader
LaRC/SSD/R. Hook

Questions concerning this study may be directed to:

R. L. Norman
John F. Kennedy Space Center
Attention: LL-MLV-A
Kennedy Space Center, Florida 32899

Telephone: (305) 853-5566

Victor A. Dulock, Jr.
TRW Systems Group
7001 N. Atlantic Avenue
Cape Canaveral, Florida 32920

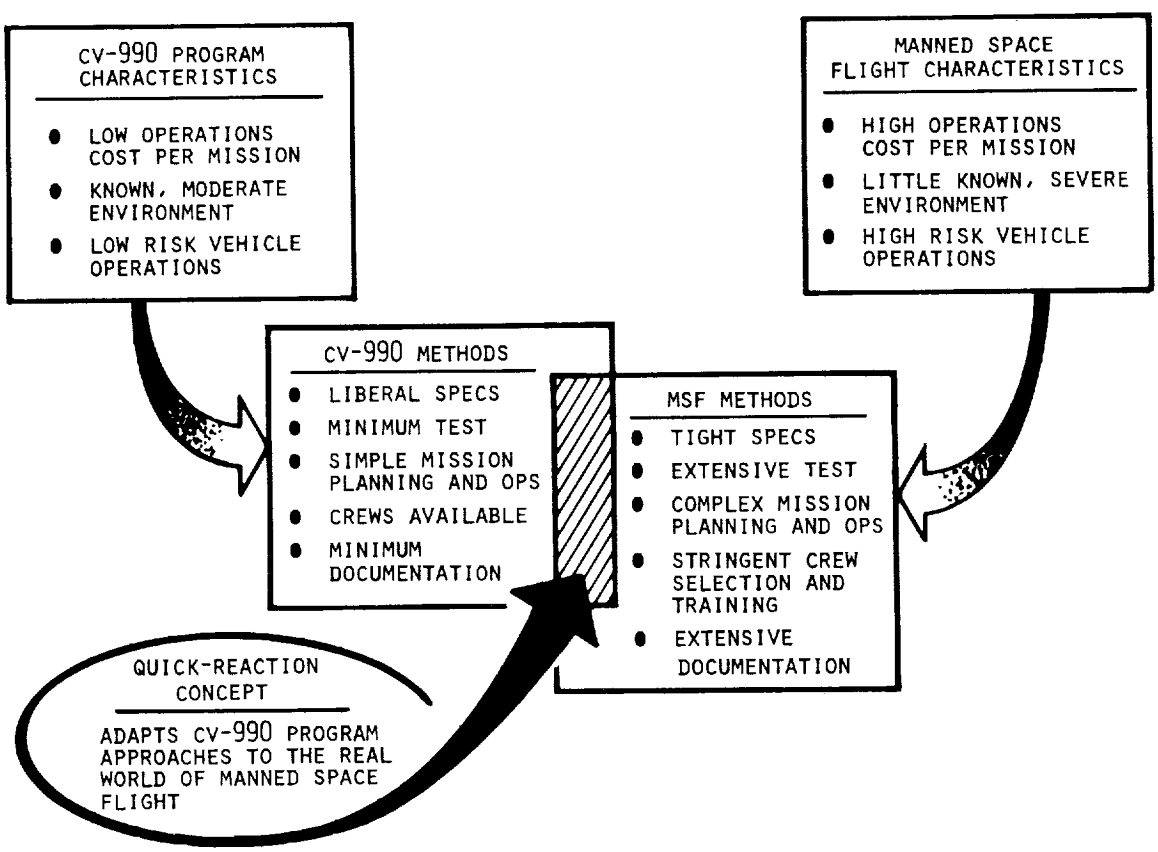
Telephone: (305) 783-0870

BACKGROUND INFORMATION

The object of this study was to develop operational concepts for a special class of space experiments in the Shuttle era which are not in the current mission model. This class has been termed "Quick-Reaction". It is to be the Manned Space Flight equivalent of the Ames CV-990 Aircraft program (see Figure). The Quick-Reaction concept is considered to be an experiment integration process, providing a rapid response to a wide variety of users (experimenters) with maximum flexibility and low cost.

The carrier baselined for these Quick-Reaction experiments is the Sortie Lab, currently being defined by the Marshall Space Flight Center. The operational Sortie Lab will be a manned module multiple experiment carrier which will remain attached to the Shuttle throughout the seven day sortie mission. Inherent in the definition of the Sortie Lab is an attached pallet. Thus, experiments can be mounted both within the module or exposed directly to the space environment on the pallet. In addition, the Sortie Lab will be equipped with support subsystems for the experiments and their operators. These include environmental control and life support, power, data management, thermal control, control and display consoles, viewing ports, airlocks, etc.

In this study an operational concept was developed for a narrow class of Shuttle Sortie missions where the experiment/carrier integration could be performed at the launch site. Experiments for this mission were specifically selected to be simple to integrate, simple to operate, multi-discipline, and from a wide variety of users.



QUICK REACTION CONCEPT

GLOSSARY

AOT	Avionics Operational Test
ASTP	Apollo Soyuz Test Program
ATL	Applied Technology Laboratories
C&D	Controls and Displays
C&W	Caution and Warning
CKAFS	Cape Kennedy Air Force Station
CRT	Cathode Ray Tube
CV-990	Convair 990 Aircraft
DOD	Department of Defense
DMS	Data Management System
ECLSS	Environmental Control and Life Support System
EO	Engineering Order
ERT	Experiment Requirements Transmittal
GSE	Ground Support Equipment
KSC	Kennedy Space Center
LPS	Launch Processing System
M&O	Maintenance and Operations
MCF	Maintenance and Checkout Facility
MEO	Manned Earth Observatories
MSFC	Marshall Space Flight Center
O&C	Operations and Checkout
PI	Principal Investigator
PIM	Payload Integration Mockup
QR	Quick-Reaction
QRI	Quick-Reaction Integration
QRSL	Quick-Reaction Sortie Lab
R&D	Research and Development
R&I	Receiving and Inspection
R&QA	Reliability and Quality Assurance
SID	Shuttle Integration Device
SL	Sortie Lab
TELTA	TEthered Lighter Than Air
TLM	Telemetry
VMMPS	Vehicle Management and Mission Planning System
WBS	Work Breakdown Structure

CONTRIBUTORS:

W. L. Akridge
H. E. Cairns
D. L. Coffeen
V. A. Dulock, Jr.
D. M. Gafford
J. B. Gardner
A. Gillies
J. L. Gregory
W. E. Lee
M. J. Lovett
R. T. Merritt
F. W. Polaski
G. J. Spengler, Jr.
E. R. Wittry

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1.0 INTRODUCTION

Current NASA planning for Space Shuttle includes sortie missions utilizing the Sortie Laboratory as a manned general purpose experiment carrier and platform. The Sortie Lab (SL) is currently being defined by the Marshall Space Flight Center (MSFC). Studies of dedicated SL's for Manned Earth Observatories (MEO), Communications-Navigation, Astronomy, Earth Resources, Applied Technology Laboratories (ATL), Plasma Physics, etc., are associated with the definition effort.

The NASA has recognized that the success of the Space Shuttle program requires the support and backing of the user community. The Space Shuttle will provide the basic capability necessary to eliminate or reduce many of the constraints and restrictions affecting experimenters on previous programs. To realize this, however, operational concepts must be developed which will provide a simple, flexible, quick-reaction, and low-cost approach to space experimentation. This study provides the definition of such a concept.

The specific study objectives were:

- To develop operational concepts and plans for "Quick-Reaction" experiment integration at the Shuttle launch site which satisfies the criteria of minimum integration, low cost, and customer responsiveness.
- To determine the time/cost impact of performing all or part of the integration activities at locations other than the launch site.

The major assumptions provided for this study were:

- In the Shuttle era all U.S. space activity will use the Space Shuttle for launch, recovery, and logistics support.
- Most payloads will be developed under the direction of NASA and/or other Government agencies other than at the Shuttle launch site.
- The configuration of major KSC and CKAFS facilities will be that which remains at the conclusion of the Skylab Program plus any major modifications for other programs prior to Shuttle operations.
- Payloads will be designed for access and repair/replacement of subsystems, when necessary, at the Shuttle launch site.
- Maximum allowable payload-dedicated orbiter ground time will not be more than one day.
- A requirement exists at the launch site to assess the launch readiness of all experiments and the payload carrier after experiment/carrier mating and to continue this assessment through launch.

In addition to the above assumptions, the following ground rules were used:

- The SL will be the Quick-Reaction (QR) experiment carrier.
- Both the SL and the Shuttle will be operational.
- The SL(s) assigned to the QR missions will be owned by the Shuttle operator at the launch site.

The study was divided into three phases with specific tasks defined for each phase as shown in Figure 1.

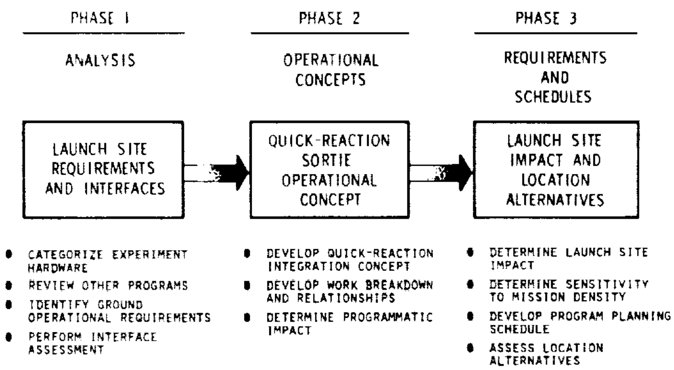


Figure 1. Study Flow

The term "Quick-Reaction" (QR) is defined for this study by descriptions of key elements. When taken collectively, these descriptions constitute the definition:

TIME: The period from experiment hardware delivery at the launch site to data return to the principal investigator (PI). The goal is a one to three month time span.

COST: Low cost experiment integration and experiment/carrier checkout operations. The use of low cost and off-the-shelf experiment hardware is encouraged.

SIMPLICITY: Experiment hardware is simple to check out, integrate onto the carrier, operate, and maintain. This does not imply that the experiment or its hardware must be simple or unsophisticated.

DOCUMENTATION: The operational concept provides management systems which result in minimum documentation requirements for the integration process. This entails the use of standard user's guides and a reliance on verbal and informal communications.

USER:(PI): The most important element in the QR concept is the user. A high reliance on the user's sense of responsibility is essential.

The user is allowed and encouraged to be highly involved throughout the entire process.

It should be noted that for this study, Quick-Reaction is NOT the rapid response to unexpected events or unpredicted targets of opportunity.

2.0 REVIEW OF OTHER PAYLOAD PROGRAMS

Several current payload programs were reviewed to discover features applicable or desirable for incorporation into the QR concept. The following programs were reviewed:

- Wallops Island Sounding Rocket Program
- "Mighty Mouse" Lightning Research Program at KSC
- Ames CV-990 Aircraft Program
- TELTA Balloon Program at CKAFS
- Delta/Centaur Unmanned Launch Programs
- Apollo/Skylab Programs

These programs encompass a broad spectrum of integration activities from the very simple to the highly complex (Table 1). The features deemed most appropriate to the QR concept are:

- High user involvement at the launch site
- Relatively simple documentation systems
- Single-point authority and responsibility in program management
- Single-point contact with the user
- Varying degrees of operational flexibility

PROGRAM	FEATURES				
	DISCIPLINE	USERS	DOCUMENTATION	TYPICAL OVERALL SPAN TIME	OTHER COMMENTS
SOUNDING ROCKETS	MULTIDISCIPLINE SINGLE EXPT/LAUNCH	GENERAL SCIENTIFIC COMMUNITY HIGH INVOLVEMENT	MINIMAL	8 to 12 MONTHS	USER ORIENTED SINGLE POINT RESPONSIBILITY
MIGHTY MOUSE	LIGHTNING RESEARCH	SINGLE PI LOW INVOLVEMENT	VERY MINIMAL	RAPID RESPONSE TO OPPORTUNITIES (HOURS)	ALL HARDWARE STANDARD WELL DEFINED OPERATIONAL PROCEDURES
CV-990	MULTIDISCIPLINE	GENERAL SCIENTIFIC COMMUNITY HIGH INVOLVEMENT	MINIMAL	3 to 12 MONTHS	USER ORIENTED SINGLE POINT RESPONSIBILITY
TELTA BALLOON	MULTIDISCIPLINE	PRINCIPALLY DOD	ALMOST NON-EXISTANT	CAN BE ON THE ORDER OF WEEKS	SMALL AND SIMPLE EXPERIMENTS FLEXIBLE NOT GENERALLY OPEN TO CIVILIAN USERS
DELTA/CENTAUR	MULTIDISCIPLINE AUTOMATED SATELLITES	LOW INVOLVEMENT AT LAUNCH SITE	MULTIPLE MGMT. RESPONSIBILITIES WITH FORMAL DOCUMENTATION	3 to 5 YEARS	MINIMUM RISK PHILOSOPHY LAUNCH SITE IS CONCERNED HOST
APOLLO/SKYLAB	MULTIDISCIPLINE MANNED	LOW INVOLVEMENT	EXTENSIVE	3 to 5 YEARS	MINIMUM RISK EMPHASIS ON PERFORMANCE ONE-OF-A-KIND HARDWARE

Table 1. Other Payload Program Features

The extremely short reaction-time programs (Balloon, Mighty Mouse) exhibited some additional desirable features:

- Standardized support hardware
- Standardized experiment hardware
- True real-time decision capability
- Well-established communications lines which allow effective verbal communications.

The last two features also apply to the CV-990 program.

3.0 QUICK-REACTION EXPERIMENT BASELINE

To effectively develop the ground operations integration requirements for the QRI concept a baseline set of typical experiment hardware was chosen. The sources were from Appendix A of the Statement of Work plus limited additional sources. The criteria for selection was based on the basic SL requirements and constraints, and integration criteria consistent with the QRI philosophy. After selection, the baseline set was categorized by ground operations requirements. The selection process is shown schematically in Figure 2.

The experiment hardware selected for the baseline is representative of most scientific disciplines and reflects typical integration require-

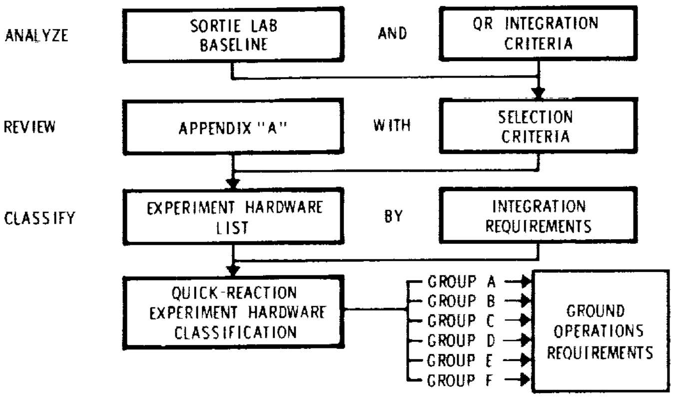


Figure 2.
Baseline Experiment
Hardware Selection Approach

ments anticipated in a QR program. A list of the selected experiments and their principal requirements is given in Figure 3.

The QR experiment hardware categories are given in Table 2.

GROUP	DESCRIPTION
A	Instruments Utilizing Cameras
B	Electromagnetic Radiation Sensors
C	Electrostatic & Magnetic Environment Sensors
D	RF Sensors
E	Ambient Environment Sensors
F	Biological Experiments

Table 2.
QR Experiment Hardware Categories

EXPERIMENT	WT LB	DIMENSIONS IN.	POWER		DATA ACQUISITION	DATA DISPOSITION - PCT			ORBITER MANEUVER REQUIREMENTS	POINTING ACCURACY DEGREE	ENVIRONMENTAL REQUIREMENTS				SPECIAL FACILITIES	CHECKOUT AREA SQ FT
			AVG WATTS	PEAK WATTS		REAL-TIME DOWNLINK	ON-ORBIT DISPLAY	RETURN SHUTTLE			CLEAN CLASS	PRESS PSI	HUMIDITY PCT	TEMP °F		
SMALL UV TELESCOPE	750	6.0 x 4.0 x 2.5 FT	20	45	FILM & DIGITAL - 500 BPS	100	100	100	MUST VIEW DIFFERENT SEGMENTS OF CELESTIAL SPHERE	±0.5	MOD	0 - 15	50	14 - 77	OPTICAL LAB PHOTO LAB	1000
IMAGE ISOCON TELEVISION	46	7.5 x 7.0 x 21.0	70	110	MAG TAPE - 240 KHz	-	10	100	NA	±0.5	100,000	15	<50	50 - 90	OPTICAL LAB	300
PHOTOMETRIC CLUSTER	30	24 x 12 x 12	25	110	MAG TAPE - 82 KBPS	-	10	100	NA	±0.5	100,000	15	<50	50 - 90	OPTICAL LAB	300
MASS SPECTROMETER	16	8 x 10 x 10	8	8	MAG TAPE - 405 BPS	-	50	100	ATTITUDE TO POINT AWAY FROM EARTH	NA	MOD	15	<50	50 - 90	OPTICAL LAB	300
ION TRAP	7.5	7 x 8 x 10	10	10	MAG TAPE - 1080 BPS	-	50	100		NA	MOD	15	<50	50 - 90		300
ELECTROSTATIC PROBE	3.0	4 x 5 x 3.5	2	2	MAG TAPE - 540 BPS	-	50	100		NA	MOD	15	<50	50 - 90		300
ELECTRIC FIELD PROBE	30	10 DIA x 6	10	10	MAG TAPE -540 BPS	-	50	100		NA	MOD	15	<5[illegible]	50 - 90		300
FLUX GATE MAGNETOMETER	6	6 x 6 x 6	5	5	MAG TAPE - 900 BPS	-	50	100		NA	MOD	15	<50	50 - 90		300
OPTICAL METEOROID DETECTOR	75	39 DIA x 39	7.5	110	MAG TAPE - 264 BPS	-	10	100	POINT AWAY FROM EARTH AVOID SHADOWING	±2.0	100,000	15	<50	50 - 90	OPTICAL LAB	300
MULTISPECTRAL RADIOMETER	40	10 DIA x 24	20	20	MAG TAPE - 2.7 KBPS	10	-	90	PRIMARY POINTING MODE IS TO NADIR	±0.5	100,000	0 - 15	30 - 70	45 - 81	OPTICAL LAB	1000
MICROWAVE RADIOMETER	450	30 dia x 36	160	160	MAG TAPE - 384 BPS	10	-	90		±1.0	MOD	0 - 15	<50	50 - 90	RF LAB	500
MULTISPECTRAL CAMERA	590	24 x 24 x 15	30	275	FILM	-	-	100		±0.5	MOD	0 - 15	<50	60 - 90	OPTICAL LAB PHOTO LAB	1000
MULTISPECTRAL SCANNER	300	30 x 20 x 60	115	270	MAG TAPE - 970 KBPS	10	-	90		±2.5	100,000	0 - 15	<50	-20 - 160	OPTICAL LAB	300
PASSIVE MICROWAVE SCANNER	250	13 x 1 x 13 FT	175	175	MAG TAPE - 2 KBPS	10	-	90		±1.0	MOD	0 - 15	<50	45 - 81	RF LAB	500
PLASTIC/NUCLEAR EMULSION	308	36 x 36 x 6	3.5	22	EMULSION SHEETS	-	-	100	ANY ATTITUDE IN ZENITH HEMISHPERE	±1.0	MOD	0 - 15	<50	40 - 90	STORAGE FOR EMULSION SHEETS	300
UV AIRGLOW HORIZON PHOTOGRAPHY	40		NA	NA	FILM	-	-	100	POINTING TOWARD EARTH'S HORIZON	±0.5	100,000	0 - 15	<50	40 - 90	OPTICAL LAB PHOTO LAB	300
UV X-RAY SOLAR PHOTOGRAPHY	25	6 x 6 x 16	7	70	FILM	-	-	100	VARIOUS ATTITUDES AWAY FROM EARTH	±0.5	100,000	0 - 15	<50	-40 - 160	OPTICAL LAB PHOTO LAB	300
L-BAND RADIOMETER	53		30	35	MAG TAPE - .18 KBPS	-	-	100	VARIOUS ATTITUDES TOWARD EARTH	±2.5	MOD	0 - 15	<50	20 - 180	RF LAB	500
SURFACE MOISTURE PHOTOPOLARIMETER	30	24 x 24 x 42	550	700	MAG TAPE - 970 BPS FILM	50	50	100	VARIOUS ATTITUDES TOWARDS EARTH	±0.5	100,000	0 - 15	<50	40 - 90	OPTICAL LAB PHOTO LAB	300
DOSIMETER	8	4 x 7 x 5	.8	.8	MAG TAPE	100	-	100	NA	NA	MOD	0 - 15	<50	-40 - 160		300
THERMAL COATINGS	6	8 x 8 x 5	NA	NA	SAMPLE PANELS	-	-	100	SAMPLES TO BE ORIENTED TOWARDS SUN	NA	MOD	0 - 15	<50	-135 - 200		300
IN-FLIGHT AEROSOL ANALYSIS	8	8 x 4 x 6	NA	NA	DIGITAL DISPLAY	-	100	100	NA	NA	100,000	0 - 15	<50	40 - 90		300
EFFECT OF ZERO G ON SINGLE HUMAN CELL	23	15 x 9 x 6.5	25	135	FILM	-	-	100	NA	NA	100,000	0 - 15	<50	50 - 95	BIO LAB PHOTO LAB	1000
CIRCADIAN RHYTHM	227	43 x 24 x 19	193	237	SELF-CONTAINED COMPUTER PROCESSING AND STORAGE	100	-	100	NA	NA	100,000	0 - 15	<50	65 - 70	BIO LAB	1000

Figure 3. Baseline QR Experiment Hardware

4.0 GROUND OPERATIONS REQUIREMENTS ANALYSIS

The purpose of this analysis was to determine the basic operational and functional requirements, and the resources necessary to accommodate the assembly, test, checkout, integration, launch, recovery and refurbishment of the QR experiments and carrier at the launch site. An overall ground operations plan was developed for the QRI activity which included all phases of a typical QR mission (Prelaunch, Launch, Mission Support, Recovery, Refurbishment). A detailed functional flow and time lines for these activities appears in the Appendix to the Detailed Technical Report.

The resources required for a QRI activity are summarized in Table 3. These resources provide support for QR experiment hardware activities, SL maintenance and integrated experiment/SL operations.

• SHIPPING TERMINAL	• SUPPORT EQUIPMENT	• INSTITUTIONAL SUPT.
• LOCAL PI LAB	• TEST EQUIPMENT	• UTILITIES
• BIOLOGICAL LAB & STORAGE	• ALIGNMENT FIXTURES & INSTRUMENTS	• COMMODITIES
• ENVIRONMENTAL QUALIFICATION FACILITY AND EQUIP	• DATA MGMT SUPPORT	• STORAGE
• OPTICAL LAB	• FILM STORAGE & DARKRM	• CRANES, HOISTS, LIFTING FIXTURES
• INTEGRATION & TEST FACILITY	• SHUTTLE INTEGRATION DEVICE	• TRANSPORTERS, DOLLIES
• CARRIER REFURBISHMENT FACIL.	• LAUNCH SYSTEMS & FACILITIES	• RF SCREEN ROOM
	• MOBILE ENVIRON. CONTROL	• GROUND SUPPORT SYSTEMS - - GASES - CRYOS - PURGES - ENVIR. CTL - GRND ELECT - VENT, DRAINS

(Note: Quick-Reaction Activity Resources Only)

Table 3.
Summary of QRI Resource Requirements

The major facilities include accommodations and equipment specifically for the QR activity. For example, the local PI labs are provided for the users at the launch/integration site for the final assembly, test, and checkout of their hardware prior to installation into the SL. The detailed requirements for these laboratories for all six experiment groups are shown in Table 4. The resultant impact of these and other requirements on the launch site are summarized in Section 10.

• LOCAL PI LAB

- CLASS 100^k CLEAN ROOM
- PERSONNEL & EQUIP AIR LOCK
- TEMP & RH CONTROL TO $73^{0} \pm 3^{0}$F & 50% RH
- 500 SF TO 2000 SF FLOOR SPACE
- 8 FT TO 15 FT CEILING
- OH CRANE TO 1 TON
- VARIABLE CONTROL LIGHTS
- VACUUM SOURCE
- DARK ROOM
- REFRIG. FILM VAULT
- GENERAL UTILITIES
- STORAGE AREA
- OFFICE AREA
- GEN'L LAB EQUIPMENT
  - • POWER SUPPLIES
  - • OSCILLOSCOPES
  - • RHEOSTAT
  - • CAMERA EQUIPMENT
  - • SERIES FUSE BOX
  - • TEST CONTROL PANELS
  - • OPTICAL ALIGNMENT EQUIP
  - • FILM DEVELOPMENT EQUIP
  - • FILM VIEWERS
  - • DATA RECORDERS
- WORK BENCHES
- LIFTING FIXTURE & CABLES
- TEST SUPPORT FIXTURE
- OPTICAL BENCH
- STORAGE CABINETS

Table 4.
Local PI Lab Requirements

A summary timeline (in working hours) of the major activities at the launch site from QR experiment hardware delivery to liftoff is shown in Figure 4. This is equivalent to approximately 2 1/2 months based on single shift operations.

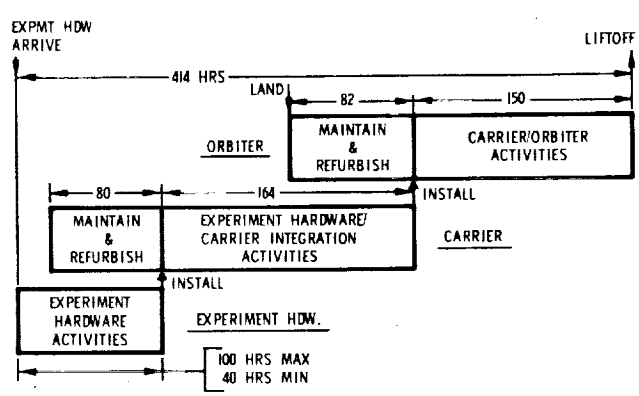


Figure 4.
Summary of QR Experiment Hardware Time at the Launch Site

5.0 INTERFACE ASSESSMENTS

As a part of the QRI requirements analysis, the need for a Payload Integration Mockup (PIM) and/or a Shuttle Integration Device (SID) at the launch site was assessed.

PIM Assessment

The PIM is currently conceived as a ground-based, operating replica of a specific payload, that is utilized to support all phases of mission operations. The criteria developed for the PIM in the Martin Marietta Study (NAS10-7685) was compared with the QR criteria developed in this study. This comparison led to the conclusion that a PIM is not required for the QR Sortie Lab at the launch site. This comparison is summarized in Figure 5.

QUICK-REACTION CRITERIA

- LOW INTEGRATION COST
- SHORT TERM OF OPERATION
- SIMPLE TO OPERATE
- EASY TO MAINTAIN
- SHORT INTEGRATION & C/O TIME

COMPARE

PIM CRITERIA

- LONG TERM P/L OPERATION
- P/L NOT READILY RETURNED FOR CONFIGURATION UPDATE
- HIGH P/L COST OR ONE OF A KIND
- USED FOR FAULT ISOLATION AND CORRECTION ANALYSIS

CONCLUSION
A PIM IS NOT REQUIRED FOR QUICK REACTION SORTIE PAYLOADS AT THE LAUNCH SITE.

Figure 5.
Comparison of PIM Criteria and QR Criteria

SID Assessment

The SID is currently envisioned as a device that presents:

- A physical replica of the Orbiter payload bay structure and equipment interfaces with the payload.
- A functional replica of the Orbiter flight systems that interface with the payload.

QR INTEGRATION CONSIDERATIONS

- QUICK-REACTION EXPERIMENTS ARE GENERALLY R&D
- RAPID INTEGRATION - GROSS ANALYSIS - MIN. UNIT TESTING
- MAX. OF ONE DAY PAYLOAD INSTALLATION AND C/O IN ORBITER
- EACH QR MISSION IS DIFFERENT
- COMPATIBILITY PROBLEMS COULD CAUSE MISSION AND PROGRAM SLIPS

COMPARE

SID FUNCTIONS

- VERIFY SAFETY AND COMPATIBILITY OF PAYLOAD WITH ORBITER
- PRECLUDE INTERFACE FIT AND ALIGNMENT PROBLEMS
- SIMULATE FUNCTIONS ACROSS INTERFACES
- WORK MUTUAL INTERFERENCE PROBLEMS BEFORE MATING

CONCLUSION
A SID IS DESIRABLE FOR QUICK-REACTION SORTIE PAYLOADS AT THE LAUNCH SITE

Figure 6.
QRI Considerations Vs SID Functions

A comparison of the QRI considerations and the proposed SID functions (Figure 6) leads to the conclusion that a SID is desirable for QR Sortie Lab payloads at the launch site. The SID should possess the functional and physical characteristics depicted in Figure 7.

FUNCTIONAL

- SIMULATE INPUTS TO PAYLOAD
- RESPOND TO PAYLOAD OUTPUTS
- SIMULATE SOFTWARE INTERFACE
- SIMULATE PROCEDURAL INTERFACE

PHYSICAL

- CARRIER SUPPORTS
- INTERFACE PANELS
- PAYLOAD BAY ENVELOPE
- SUPPORT EQUIPMENT FOR CARRIER SYSTEMS
- SUPPORT EQUIPMENT FOR INPUTS AND OUTPUTS

Figure 7. SID Characteristics

Even though consideration of other Shuttle payloads was beyond the scope of this study, it is likely that the "Shuttle Operator" will require all payloads to demonstrate compatibility with Shuttle interfaces through the SID or a similar device, before installation into the payload bay.

6.0 OTHER REQUIREMENTS AND FACTORS

The QR concept emphasis is service to the user, whoever he may be. The sponsorship of QR experiments may sometimes be outside of NASA. In these cases, the sponsor will expect to levy development requirements on the user, and NASA's interest will generally be limited to safety and compatibility considerations.

Certain classes of potential sponsors and/or users merit special attention both because of their importance and the fact that they present a rather large potential user market:

- Department of Defense (DOD)
- Commercial Users
- Foreign Users

An assessment of their special requirements and the potential impact they may have on a QR program is given in the succeeding paragraphs.

DOD

The potential impact of DOD hardware is not significant, since it would not differ in its essential characteristics from other state-of-the-art hardware. However, special consideration must be given to the security aspects of DOD projects. This may result in:

- Sharing of the QR facilities between DOD and other users on a non-interference basis
- Dedicated DOD facilities
- Dedicated DOD QR missions

Commercial Users

The QR concept appears to be ideally suited to the desires of commercial users in that it is cost-effective and exerts minimal external controls.

The potential impact of commercial users on the QR activity occurs in two principal areas:

- Special Agreements - In most instances the commercial user will require agreements with respect to costs for services and liability.
- Proprietary Factors - Some commercial users may consider their hardware, software, and/or data to be proprietary. For these cases safeguards will have to be established to satisfy the concerns of those users.

Foreign Users

The impact of foreign users from the developed nations on the QR program is expected to be minimal. This conclusion is in agreement with the assessment and conclusions resulting from the study results of contract NAS10-7685.

Consideration of users from the "emerging" nations leads to a different conclusion. The political instability of many of these nations tends to hinder long-term projects making the QR concept particularly attractive. Typically, these users are academically strong (many educated in the U.S.) but weaker in the practical aspects of hardware fabrication and test than their American counterparts. This will invariably lead to lower instrument integrity, delivery delays, increased checkout (C/O) and integration times. These users will also require increased assistance and equipment once they arrive at the launch site.

7.0 QUICK-REACTION INTEGRATION CONCEPT

Overview

The intention of the QR concept developed in this study is to:

- Provide a program to serve a wide variety of investigators in the Shuttle era.
- Provide a program which has a relatively short integration time (one to three months) from hardware delivery to data receipt by the user.
- Fly experiment hardware which is simple to integrate, operate and maintain.

Any QR concept developed must also, as a minimum, satisfy the gross systems requirements in the three categories shown in Figure 8. These requirements can be met by the performance of the QRI functions shown on the left in Figure 9. The QRI operation, however, must fit into the context of total Shuttle program operations, with many interfaces apparent as shown on the right of Figure 9.

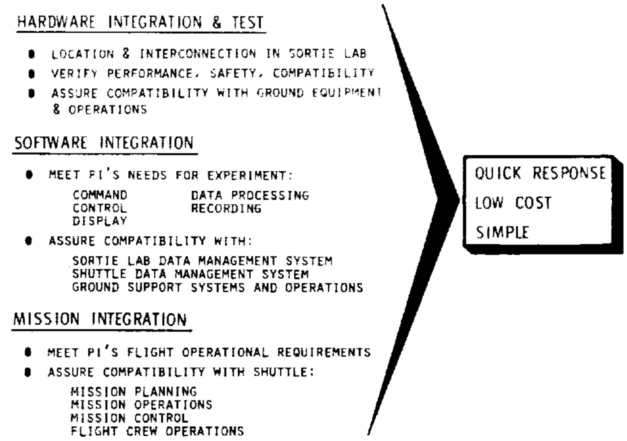


Figure 8. QR System Requirements

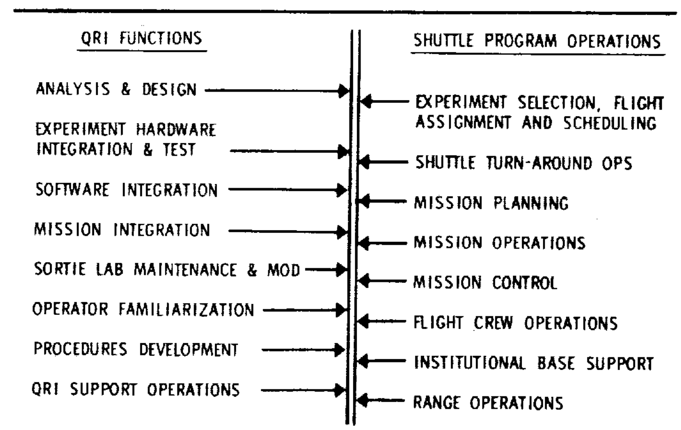


Figure 9.
Major QRI Elements and Interfaces

Hardware Integration

The principal functions comprising the QRI concept are sequenced and inter-related as shown in the functional flow diagram of Figure 10.

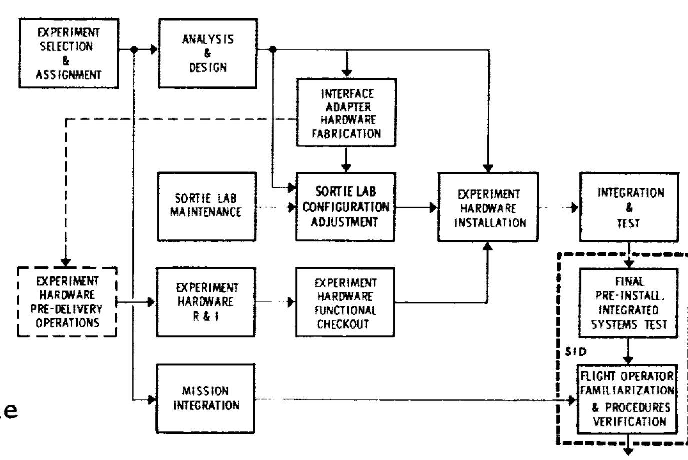


Figure 10. QRI Concept Flow

Certain functions depicted on this flow should be noted:

- The Analysis and Design function supports experiment hardware fabrication, and SL configuration adjustments with appropriate drawings, sketches, and procedures. This function may also support the Experiment Selection and Assignment function with various analyses and trade-offs (e.g., structural, thermal, mass properties, power, trajectories, TLM requirements, attitude requirements, etc.).
- The Interface Adapter Hardware Fabrication function provides mechanical and electrical outputs for interfacing experiment hardware to the SL. These outputs include such things as adapters, fluid lines, mounting fixtures, cables, test aids, etc.
- Certain interface adapter hardware may be supplied to the user at his home lab thereby decreasing the possibility of later installation and fit problems at the launch site.
- Laboratory facilities will be provided at the integration/launch site for the QR users (PI's). These labs allow the users to perform their Receiving and Inspection (R&I), functional checkout, and final calibrations and adjustments. To facilitate the use of these labs the user specifies his requirements to the integration site on an Experiment Requirements Transmittal (ERT) sheet which is contained in the QR User's Guide (Section 8). These activities are depicted in Figures 11 and 12.
- The QR experiment checkout procedures are at the discretion of the user, and are relatively informal with a minimum of imposition on the user. Exceptions are requirements to verify that all safety and compatibility specifications have been met. There is no effort to influence experiment operations which do not interfere with Shuttle operations or compromise mission objectives.

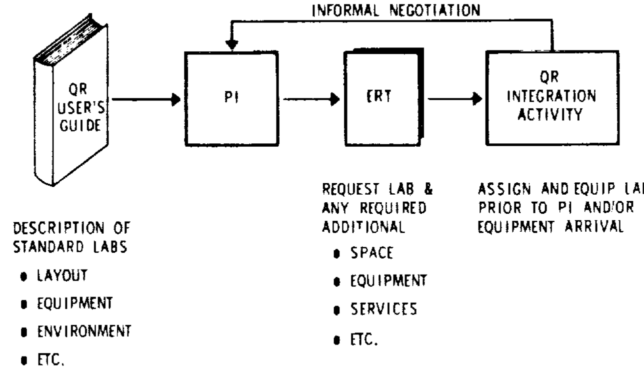


Figure 11. User Lab Assignment

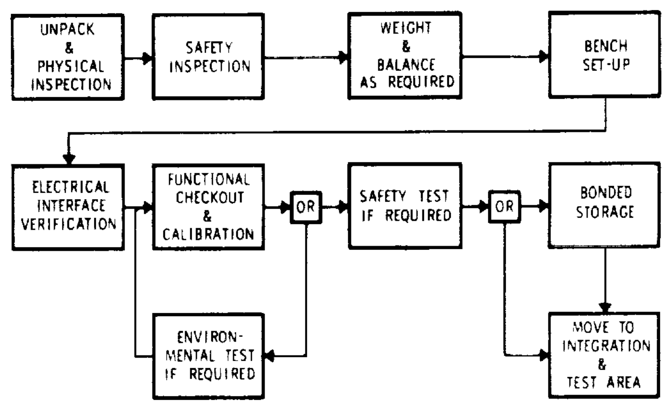


Figure 12.
QR Experiment Hardware Checkout Flow

- The Sortie Lab Maintenance function provides scheduled and unscheduled maintenance operations on the SL subsystems and components. The principal maintenance activities include:
  - Environmental Control and Life Support Systems (ECLSS)
  - Fuel Cells and Power Distribution System
  - Data Management System (DMS)
  - Gas and Fluid Systems
  - Crew Compartment
  - Controls and Displays (C&D)
  - Cleanliness

- The experiment installation, integration, and test are performed in a QR Maintenance and Test Stand (Figure 13). The basic functions performed here are given in Table 5.

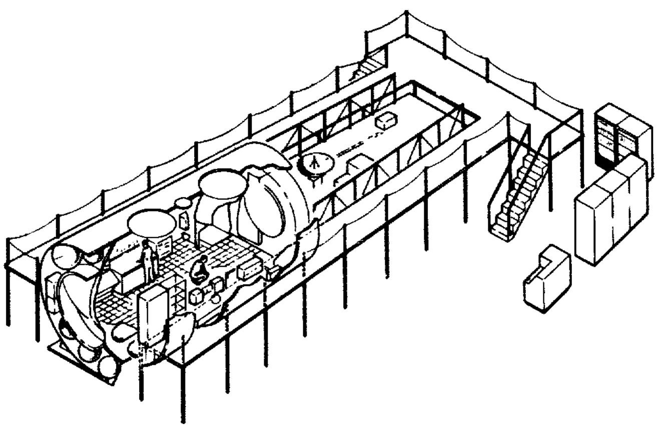


Figure 13.
QR Maintenance and Test Stand

- EXPERIMENT INTERFACE ADAPTER HARDWARE INSTALLATION
- EXPERIMENT INSTALLATION
- SAFETY VISUAL INSPECTION
- EXPERIMENT-TO-SORTIE LAB INTERFACE CHECKS
- EXPERIMENT ALIGNMENT & CALIBRATION
- INDIVIDUAL EXPERIMENT TURN ON/FUNCTIONAL OPERATION*
- SAFETY SPECIFICATION CONFORMITY CHECKS
- INTEGRATED EXPERIMENT AND SORTIE LAB SUBSYSTEMS TURN ON, FUNCTIONAL OPERATION, AND OVERALL COMPATIBILITY ASSESSMENT*
  - INTER-EXPERIMENT
  - EXPERIMENT-TO-SORTIE LAB
  - EXPERIMENT & SORTIE LAB-TO-SHUTTLE (SIMULATED INTERFACE)
- FLIGHT OPERATOR FAMILIARIZATION/TRAINING
  - FIRST TIME WITH EXPERIMENT FLIGHT HARDWARE INTEGRATED

* USING GROUND POWER AND SIMULATED ORBITER DMS.

Table 5.
QR Maintenance and Test Stand Functions

- The SID is used to demonstrate that the payload is compatible with the Orbiter, and for flight operator familiarization and flight procedures verification (Figure 14).

DEMONSTRATES SORTIE LAB READINESS TO THE SHUTTLE OPERATOR

PROVIDES OR SIMULATES -
- ORBITER-SUPPLIED COMMODITIES AND ORBITER-SHARED SYSTEMS FUNCTIONS (ELECTRIC POWER, GASES, ENVIRONMENT CONTROL, ETC.)
- ORBITER DMS
- ORBITER PAYLOAD CONTROL & MONITOR FUNCTIONS
- ORBITER DOWNLINK - INCLUDING DATA RECORD CAPABILITY
- PAYLOAD BAY ENVIRONMENT
- INPUT TO ORBITER WEIGHT & BALANCE DETERMINATION
- FLIGHT OPERATOR FAMILIARIZATION

VERIFIES -
- ORBITER-SORTIE LAB HARDWARE AND FUNCTIONAL INTERFACES
- ORBITER-SORTIE LAB FLIGHT SOFTWARE COMPATIBILITY
- SHUTTLE SAFETY SPECIFICATION COMPLIANCE
- EXPERIMENT FLIGHT OPERATING PROCEDURES

Figure 14.
Shuttle Integration Device

The features of the hardware integration activities for the QR concept, as outlined, are summarized below:

- Rapid accommodation of experiment hardware into SL
- Analysis and Design - small group, heavy reliance on standard computer simulations
- Early interface adapter hardware fabrication, in a Model Shop or equivalent, available to user
- Maintenance and Test Stand - QR dedicated, relatively low cost
- SID - Pre-installation compatibility demonstration of SL and installed experiments with Orbiter

Software Integration

Integration of the QR experiments into the SL must consider the data management and computational software requirements of each experiment as well as that of the SL. In addition, consideration must be given to the experiment/SL Data Management System

(DMS) and the SL/Orbiter DMS interfaces. These requirements may include the following elements:

- On-board data processing
- Data downlink
- Data processing of TLM data
- On-board control and display (C&D)
- On-board caution and warning (C&W)
- Data recording

These requirements will differ among the experiments. Some will require little or no software integration, while others may include one or more of the elements listed above. A software requirements analysis of the baseline set of experiments used in this study showed that:

33% required data downlink

45% required on-board display

66% required recording on magnetic tape

In addition, a survey of 10 potential PI's who expressed an interest in the QR concept indicates that:

30% desire downlink capability

40% desire real-time processed data

60% desire some form of control and display

50% desire DMS recording

A simplified diagram illustrating the proposed software integration concept for those QR experiments with software requirements is presented in Figure 15. Four principal locations are shown. In his home lab, the PI develops his experiment software,

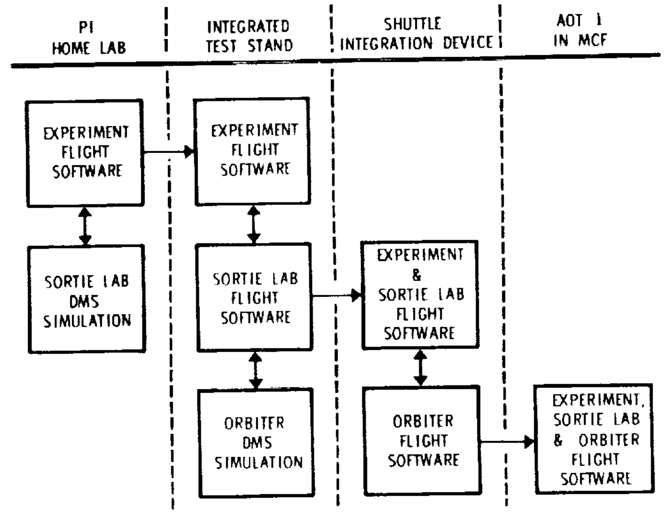


Figure 15.
QR Software Integration Concept

and its compatibility with the Sortie Lab DMS is achieved through the use of a DMS simulation. In the Maintenance and Test Stand, the experiments and SL flight software are integrated, using a simulation of the Orbiter DMS. The SID allows final integration of experiment, SL, and Orbiter flight software, so that no unforeseen software problems should occur in the Avionics Operational Test (AOT) in the Maintenance and Checkout Facility (MCF).

Integration of the experiment data requirements into the SL and Orbiter DMS may be accomplished through the planned KSC Launch Processing System (LPS). This computer-based system is being developed to reduce launch processing costs and to meet Orbiter turnaround requirements. It is a universal system, designed for all upcoming systems; i.e., Space Shuttle, Space Tug, Space Station, etc.

Its objectives are to:

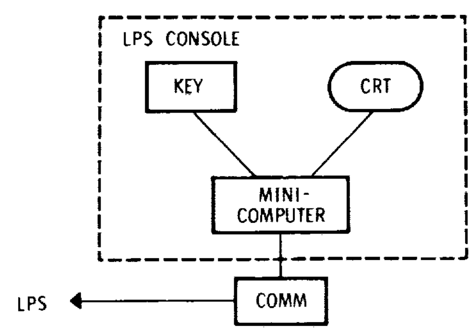
- Reduce operating costs through automation
- Meet vehicle turnaround requirements

The functions supported by LPS are:

- Vehicle assembly, c/o, and launch
- Landing, deservicing, and safing operations
- Maintenance and refurbishment
- GSE and facility operations
- Payload and kickstage operations
- Logistics, scheduling, status reporting, etc.

For those experiments involving experiment software development and integration, it may be advantageous to supply a terminal for PI use in his home laboratory, to provide an interface with the Sortie Lab DMS simulation on the LPS computer. This terminal may be of the simple teletype variety, but when warranted by the software requirements, an LPS terminal may be loaned to the PI. This permits the PI to read the Sortie Lab DMS simulation into his LPS console mini-computer. He can then develop and integrate his experiment software without tying up long-distance lines for extended period of time.

This permits the same software and computer interface to be used both in the PI's home laboratory and after experiment equipment arrival at the launch site. The Sortie Lab DMS simulation is available to the PI in his home laboratory via slow rate, low-cost telephone circuits. In turn the PI's software data is available to the QRI activity computer network to provide up-to-date information during the development process of each experiment (Figure 16). As a consequence, the integration of the SL software and the software of the several experiments is largely completed before formal integration tests are initiated at the QRI activity.



- FOR MORE COMPLEX EXPERIMENT SOFTWARE INTERFACES.
- PROVIDES SORTIE LAB DMS SIMULATION ON MINI-COMPUTER.
- PROVIDES PI ACCESS TO LPS DATA BASE AND COMPUTATIONAL CAPABILITY.
- PERMITS INTEGRATION OF SOFTWARE CONCURRENT WITH HARDWARE/SOFTWARE DEVELOPMENT.
- ACCESS TO PI SOFTWARE BY QR INTEGRATION ACTIVITY.
- MINIMIZES DATA TRANSMISSION PROBLEMS AND COST.

Figure 16.
Pre-Delivery QR Software
Integration Concept

At the QRI activity, individual experiment checkout is accomplished using a software interface identical to that utilized during the development phase in the PI's home laboratory.

In summary, the proposed QR software integration concept takes advantage of state-of-the-art data transmission techniques and is based on maximum use of modular software. Properly designed and implemented, it can provide a simple and cost-effective means of meeting user data management system requirements. The principal features of the QR software integration concept are:

- Assures compatibility of experiment, SL, and Orbiter flight software prior to payload installation.
- Assures compatibility of flight software and launch processing ground software prior to Orbiter checkout operations.
- Permits pre-delivery integration of experiment software.
- Permits PI to have common software interface in
  - Home lab
  - Integration site lab (pre- and post-flight)
- Permits optimum use of SL and Orbiter DMS capabilities by experimenters.

Mission Integration

The third major element of the QRI concept is mission integration. This function integrates the experimenter's flight operations requirements into the overall Shuttle flight operations. Typical experiment flight operational requirements and Shuttle operations are depicted in Figure 17.

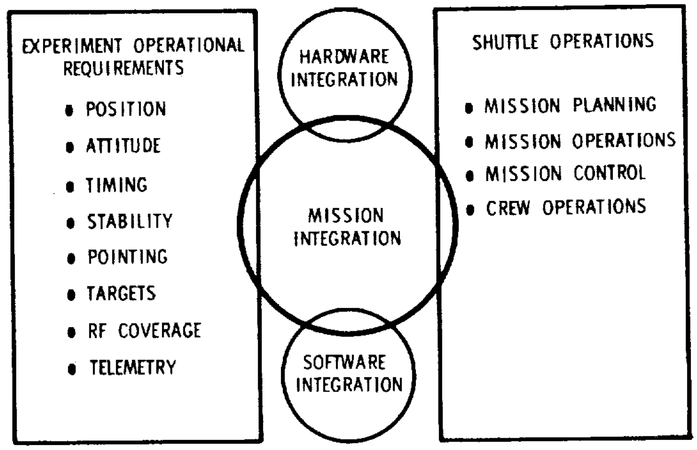


Figure 17.
Mission Integration Function

Experiment operational requirements will differ among the experiments, being dependent on the specific nature and objectives of the experiment. For example, a flight operations requirements analysis of the baseline set of experiments used in this study showed that:

60% require stability and control

75% require a specific attitude

80% require a specific knowledge of position

In addition, the previously mentioned survey of potential users indicated that:

100% desire a specific attitude

50% desire stability and control

100% desire specific knowledge of position

Considerable effort is underway to automate and streamline the mission planning function for the Shuttle era. Among these efforts are the Vehicle Management and Mission Planning System (VMMPS) and several experiment flight operations scheduling computer programs. The trend will be toward:

- Automated fast-response planning
- Reduced iterations
- Reduced mission-peculiar procedures and data
- CRT displays

However, the essential functions of the current mission planning system will be retained, although implementation may undergo considerable change. Some of these functions are:

- Flight assignment
- Mission requirements definition
- Trajectory development
- Timeline development
- Data priorities establishment
- On-board data development

The proposed QR mission integration concept takes into account these trends and the related essential functions. Figure 18 depicts the proposed QR mission integration concept.

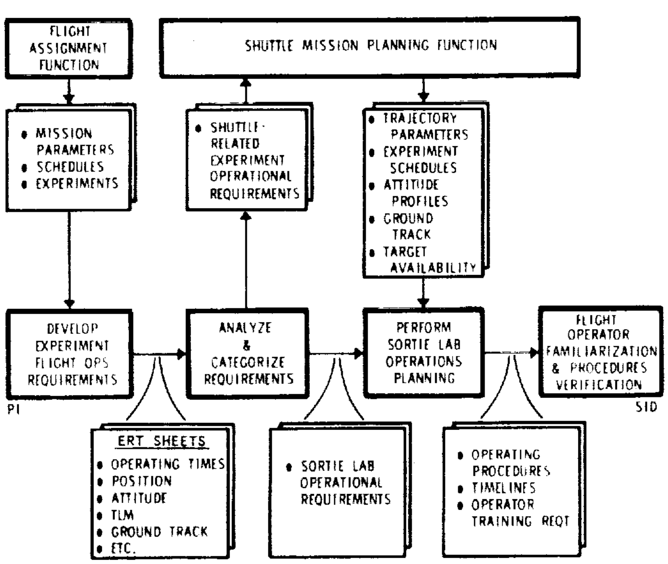


Figure 18.
Mission Integration Concept

The flight assignment function supplies the basic mission profile, flight schedule, and assigned experiments. The PI then develops his detailed experiment flight operational requirements and submits these on the Experiment Requirements Transmittal (ERT) sheets to the QRI activity. Those requirements affecting Shuttle flight operations are transmitted to the Shuttle Mission Planning Function, which performs detailed flight planning, trajectory design, and related functions. Those experiment flight operational requirements relating exclusively to internal SL and QR experiment operations are handled by the QRI activity. Detailed flight operating procedures and timelines are developed for the experiments, in consonance with the Shuttle trajectory and timelines, and in close coordination with the PI's. The experiment flight operators verify these procedures in the SID.

The proposed mission integration concept greatly simplifies the process of integrating the experiment flight operational requirements into Shuttle mission planning. It provides a single-point interface for the PI, and shields him from the complex mission-planning activities. It takes full advantage of the Shuttle Mission Planning capabilities, relying on that activity to develop integrated experiment operating timelines for the mission. However, it eliminates from the Shuttle Mission Planning function responsibility for SL or QR experiment-peculiar functions; e.g., the detailed operating procedures for a camera. The concept also provides for experiment flight operator familiarization and procedures verification without the use of special simulators, using instead the flight SL in the SID.

In summary, the features of the proposed QR mission integration concept are:

- Provides single-point interface for QR users.
- Supplies only pertinent data into Shuttle mission planning function.
- Allows for informal, rapid development of experiment flight operations procedures and timelines.
- Uses SID and flight hardware for crew familiarization and procedures verification - no simulators.

User Involvement

A major element and an original goal of the QR concept is a high relaince on the user's sense of responsibility. Specifically, the user is to retain responsibility for his experiment throughout the process. NASA provides the services and assures that all mandatory safety and compatibility criteria are satisfied. However, it is the user who determines the degree of redundancy or reliability, type of data, experiment objectives, etc. for his experiment. A summary of the responsibilities of various parties involved for the major QRI activities is shown in Figure 19.

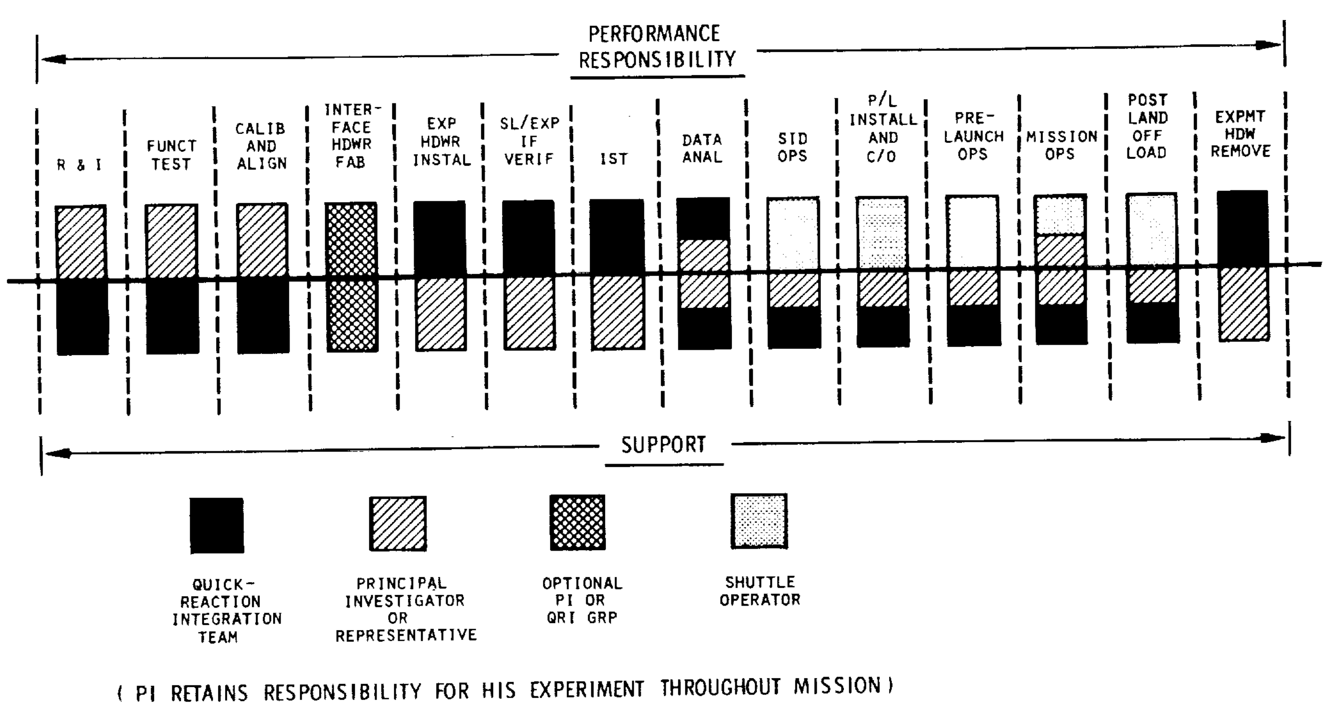


Figure 19. User Involvement

8.0 IMPACT ON PROGRAMMATIC FUNCTIONS

Configuration Control

The configuration control concept developed for the QR sortie operations is simple and straightforward. Upon receipt of the experiment requirements from the PI, the QR Integration Engineering group performs an interface analysis to determine the best way to accommodate the hardware in the SL. By effective use of the QR User's Guide and adequate informal coordination between the PI and the QR Integration Engineering group, the great majority of the experiment hardware can be installed without SL configuration adjustments or adapter hardware fabrication. However, any changes to the SL are controlled by releasing Engineering Orders (EO's) against the SL drawings through the action of a review board. Upon approval, the adjustments are performed.

Interface adapter hardware may be needed to permit installation of experiment hardware into the SL. This hardware is not formally controlled, since it is normally used only once with a specific package of experiment hardware. Sketches are used to fabricate this hardware rather than formal drawings; however, these drawings are filed and kept for configuration history purposes.

Safety

In the Shuttle era, safety specifications will be imposed by the Shuttle operator. As one of the Shuttle users, the QR Payload Operations will have to demonstrate compliance with the safety specifications through formal procedures, tests, inspections and sign-offs.

Continuation of present safety requirements and procedures in manned spaceflight will preclude the implementation of the QRI concept, particularly with respect to the one- to three-month integration time span.

To permit quick-reaction integration of Shuttle payloads, NASA should provide:

- Minimum mandatory design and test specifications for all Shuttle payloads. Leave the imposition of discretionary safety specifications to the option of the payload developers.
- New or revised safety requirements reflecting the Shuttle capabilities and Shuttle era technology; i.e., an operational vehicle as opposed to an R&D missile.

Finally, of the five generally accepted ways to verify safety compliance (inspection, similarity, analysis, demonstration, test) the use of one or more of the first four should be emphasized. Testing should be used as a last resort, as it is the most costly and time consuming.

Reliability and Quality Assurance (R&QA)

One of the ground rules for this

study is that the SL and Shuttle will be operational during the time frame considered. Furthermore, maintenance of the SL will be performed and controlled in the same manner as the Shuttle and, in some instances, common facilities utilized. Therefore, the R&QA function should be performed by the Shuttle operator. Experiment integration, including interface adapter hardware design and fabrication, is R&D in nature, and should be controlled by safety and compatibility specifications only. Since these specifications will apply to all other payloads as well as to the Space Shuttle, the R&QA function (i.e., approval of formal test and inspection procedures and formal test surveillance) will be performed by the Shuttle operator. Engineering liaison will be performed by the QR function.

Documentation

The proposed documentation concept for the QR Payload Operations is depicted in Figure 20. The handbooks prepared by the various developers (Shuttle, Sortie Lab, Networks) provide the basic input data for the development of a "QR User's Guide". This standard document allows the user to develop his specific experiment integration requirements which may be in the form of "fill in the blank" tear-out sheets in the "QR User's Guide".

Other documentation flows between the QR Payload Operations and external groups are shown in the figure. Note that the documentation loop between the QR group and the user is particularly simple and straightforward.

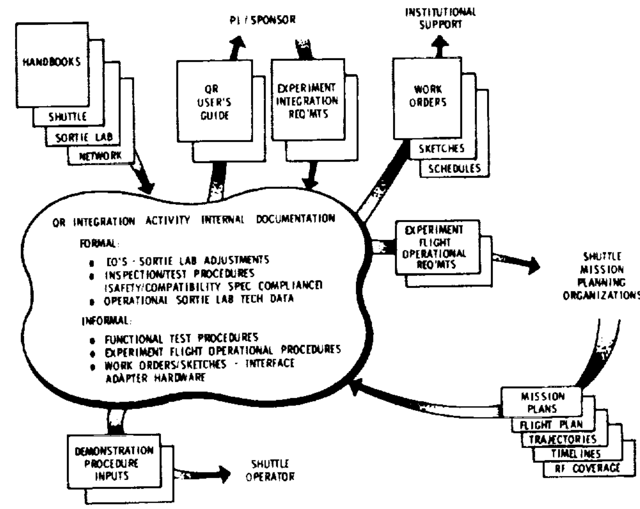


Figure 20.
QR Documentation Concept

QR User's Guide

A QR User's Guide has been mentioned previously. It is recommended as the method of disseminating information about the QR program to the user community. The guide should:

- Describe the Shuttle program, and capabilities, SL and subsystems, QR program, policies, and procedures.
- Delineate facilities, interfaces, specifications, requirements, and schedules.
- Guide experiment design and integration requirements.
- Provide experiment requirements transmittal sheets for the user to communicate his experiment requirements to the QR integration site.

The QR User's Guide is not proposed as an original document. Rather, it would consist of information from other user's guides currently proposed, coupled with data from other sources which would be pertinent to a QR user (Figure 21). In addition, it would provide specific information on the QR program, policies, and procedures.

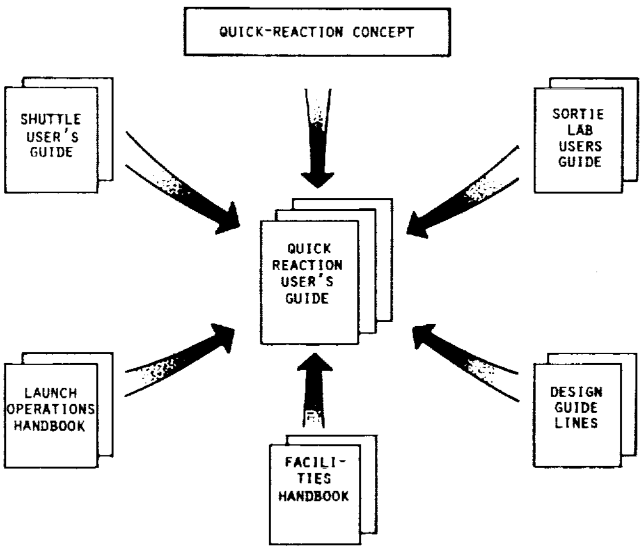
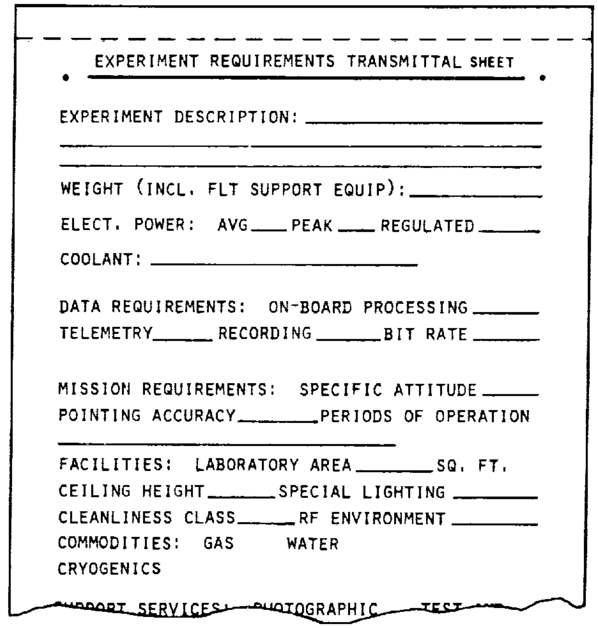


Figure 21. QR User's Guide

A unique aspect proposed for the QR User's Guide is the inclusion of QR Experiment Requirements Transmittal sheets (Figure 22). The purpose would be to provide a convenient and efficient means of conveying user's requirements to the QR group. In addition, they provide preliminary information for early preparation of user laboratories at the integration site and initiate communications with the user.



EXPERIMENT REQUIREMENTS TRANSMITTAL SHEET

EXPERIMENT DESCRIPTION: ____________

WEIGHT (INCL. FLT SUPPORT EQUIP): ____________

ELECT. POWER: AVG ____ PEAK ____ REGULATED ____

COOLANT: ____________

DATA REQUIREMENTS: ON-BOARD PROCESSING ____
TELEMETRY ____ RECORDING ____ BIT RATE ____

MISSION REQUIREMENTS: SPECIFIC ATTITUDE ____
POINTING ACCURACY ____ PERIODS OF OPERATION ____

FACILITIES: LABORATORY AREA ____ SQ. FT.
CEILING HEIGHT ____ SPECIAL LIGHTING ____
CLEANLINESS CLASS ____ RF ENVIRONMENT ____
COMMODITIES: GAS WATER
CRYOGENICS

SUPPORT SERVICES: PHOTOGRAPHIC

Figure 22.
QR Experiment Transmittal Sheet

9.0 ROLES AND RELATIONSHIPS

Work Breakdown Structure (WBS)

The top level WBS shown in Figure 23 puts the QR payload operations in program context.

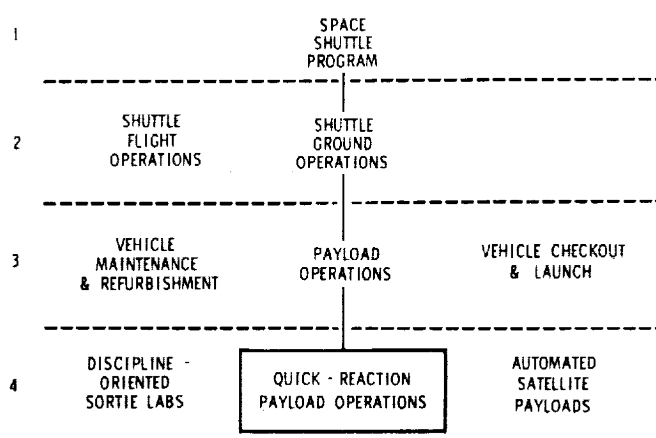


Figure 23.
QRI Concept -
Work Breakdown Overview

4 QUICK-REACTION PAYLOAD OPERATIONS

Level	QRI PLANNING & CONTROL	INTEGRATION ENGINEERING	SORTIE LAB MAINTENANCE & MODIFICATION	EXPERIMENT INTEGRATION & TEST	EXPERIMENT SOFTWARE INTEGRATION	QR MISSION INTEGRATION
5						
6	PLANNING	ANALYSIS	SUBSYSTEM MAINTENANCE	INTERFACE HARDWARE FABRICATION	SORTIE LAB DMS SIMULATION DEVELOPMENT & MAINTENANCE	FLIGHT ASSIGNMENT ANALYSIS SUPPORT
	SCHEDULING	DESIGN	SUBSYSTEM TEST & C/O	HARDWARE INSTALLATION	PROVIDE SHUTTLE DMS SIMULATION	EXPERIMENT FLIGHT OPERATIONS REQUIREMENTS
	CONFIGURATION CONTROL	SAFETY & COMPATIBILITY SPEC REVIEW	SYSTEM C/O	INTEGRATION & TEST	PI SOFTWARE DEVELOPMENT LIAISON	EXPERIMENT FLIGHT OPERATIONS PROCEDURES
	DOCUMENT CONTROL	TEST REQUIREMENTS	MODIFICATION	DATA ANALYSIS & EVALUATION	SHUTTLE FLIGHT SOFTWARE LIAISON	FLIGHT OPERATOR FAMILIARIZATION
	ADMINISTRATION	ENGINEERING LIAISON		POST-FLIGHT EXPERIMENT HARDWARE REMOVAL	EXPERIMENT-SORTIE LAB FLIGHT SOFTWARE VERIFICATION	
	LOGISTICS			TEST PROCEDURES		
	MISSION MANAGEMENT					

Figure 24. QRI Concept - Detailed WBS

The specific functions necessary to implement the QRI concept are shown in the WBS in Figure 24. These functions have been grouped under the six headings shown at the fifth level. For completeness, the "QRI Planning and Control" function has been added to the five functions discussed earlier.

A natural division or split occurs at the fifth level of the WBS. With the exception of Planning and Control, which is an administrative function, all the functions are either operational or R&D oriented.

Those functions associated with SL maintenance are repetitive, and hence, operational in nature.

On the other hand, those Level 5 functions concerned with the QR experiments are R&D in nature. Experiments will change from mission to mission and hence so will the Software, Mission, and Hardware Integration requirements. Also, experiment hardware is normally R&D in nature with emphasis on the Research aspects. In many cases, the experiment hardware may not be specifically designed for the SL carrier. The QRI activity must then, in close consultation with the involved PI's, perform the analysis and develop the associated tests and procedures to assure final systems compatibility and safety.

This natural division between operational and R&D activities is illustrated in Figure 25.

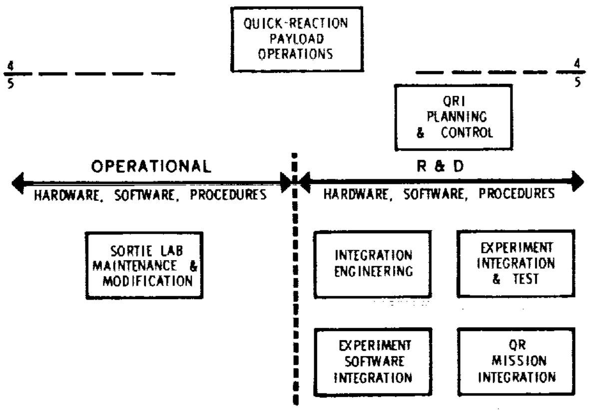


Figure 25.
QRI Concept -
Level 5 WBS Functional Groupings

Sortie Lab Maintenance Concept

The SL and the Shuttle are similar in many respects; both are man-rated operational vehicles as opposed to R&D, both have many generically common subsystems and components (e.g., fuel cells), and their ground and flight operations are essentially integrated. In addition, the technical data, configuration control, safety, reliability, quality assurance, and logistics support requirements are closely related for each vehicle. Consequently, it is logical to conclude that the most efficient and effective approach to SL maintenance is to employ the Shuttle concepts, methods and procedures that exist at the time the QR Sortie Program is initiated. The rationalé for this conclusion is summarized in Figure 26.

- BOTH THE SORTIE LAB AND SHUTTLE ARE OPERATIONAL (GROUND RULE)
- SHUTTLE OPERATOR OWNS SORTIE LAB (GROUND RULE)
- SORTIE LAB & ORBITER HAVE FOLLOWING SIMILARITIES:
  - MAN-RATED AEROSPACE FLIGHT HARDWARE
  - COMMON SUBSYSTEMS (GENERIC, AT LEAST)
  - INTEGRATED GROUND OPERATIONS (MCF, VAB, PAD, L&S)
  - INTEGRATED FLIGHT OPERATIONS
- SORTIE LAB & ORBITER HAVE SIMILAR REQUIREMENTS FOR:
  - TECHNICAL DATA
  - CONFIGURATION CONTROL
  - INDUSTRIAL, PAD & FLIGHT SAFETY
  - R&QA
  - LOGISTICS SUPPORT

CONCLUSION: SORTIE LAB MAINTENANCE AND MODIFICATION OPERATIONS SHOULD EMPLOY SHUTTLE CONCEPTS, METHODS AND PROCEDURES.

Figure 26.
SL Maintenance Concept Rationalé

This conclusion suggests the consolidation of field maintenance shops for SL and Shuttle subsystems and components maintenance at the launch site.

The performance and support responsibilities of the various groups working with the Shuttle and SL are shown in Figure 27.

To illustrate the intent of the figure, consider the "Shuttle Integration Device" function. The Shuttle Operator has primary responsibility for the operation of this device because its use demonstrates the compatibility of the SL with the Orbiter. In performing this demonstration, however, it is necessary to operate the SL systems and the QR experiment hardware. Consequently, support is needed from the SL Maintenance Team and the QR Integration Team to operate their systems during the demonstration runs.

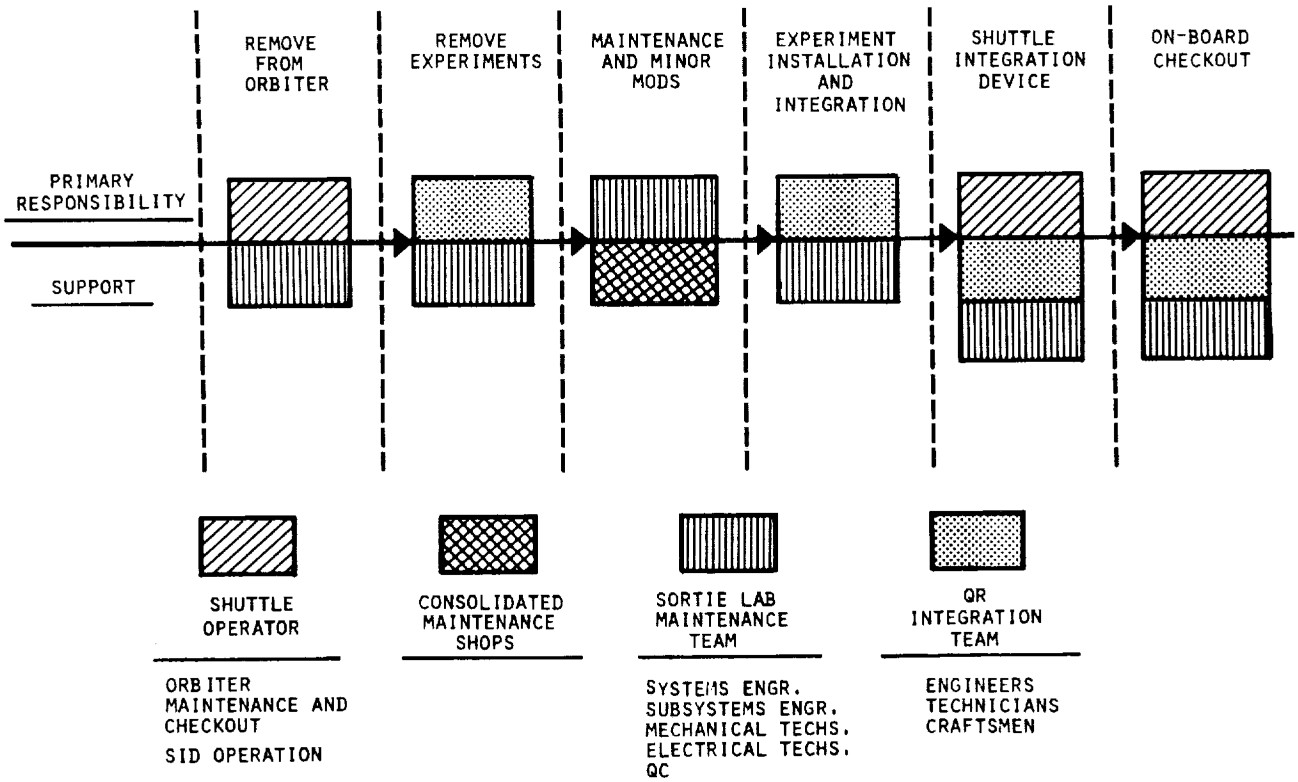


Figure 27. QR Ground Operations Roles and Responsibilities

The various experiment PI's are considered to be active participants on the QR Integration Team.

Artisan Approach

An "artisan" approach to the QRI concept is recommended and is based on TRW experience with automated satellite programs. Basically, the artisan team is a relatively small group of highly skilled and versatile engineers, technicians and craftsmen. They participate in the design and fabrication of adapter hardware, perform experiment installation, and conduct integrated testing of the experiment flight hardware in the SL. This continuity reduces transfer of responsibility and documentation. It also allows a closer PI/integration team working relationship, and stimulates PI involvement. The key features of this approach are:

- Relatively small team.
- Highly skilled engineers, technicians and craftsmen.
- Individuals are versatile and responsible.
- Provides continuity of design, fabrication, installation and integration.
- Fits national trend: i.e., restore pride in workmanship.

Model Shop

Three alternative methods are available for interface adapter hardware acquisitions:

- Procure all interface adapter hardware.
- Fabricate interface adapter hardware in "model shop" - procure special items.
- Fabricate interface adapter hardware on work order to base shops - procure special items.

An analysis was performed to determine the best approach to interface adapter hardware fabrication from the QRI standpoint. The "model shop" approach was selected.

Summary of Roles and Relationships

A summary of the primary roles and relationships developed as a result of the WBS for the QRI concept are listed below:

- QR payload operations are divided at the experiment hardware (R&D)/Sortie Lab (operational) interface.
- QR experiment integration (hardware, software, mission) is performed by a highly skilled artisan group, with extensive involvement of the PI's.
- Interface adapter hardware fabricated in "model shop" - special items procured as required.
- SL maintenance and adjustment activities use standard Shuttle ground operational concepts, methods, and procedures.
- Shuttle and SL maintenance could be consolidated at field maintenance shop level.

10.0 LAUNCH SITE IMPACT

In assessing the impact of the implementation of QR activities at the Shuttle launch site, the following guidelines and assumptions were invoked:

- Maximum utilization of existing facilities.
- Four QR Sortie flights/year.
- One QR Sortie Lab owned by the launch site.
- Single shift operations.

Facilities/Equipment

The facility requirements for the proposed concept are:

10,000 sq ft work area for the QR Sortie Lab

7,500 sq ft of floor space for PI labs

2,000 sq ft of floor space for an environmental qualification lab

The ground support equipment requirements are:

- GSE and systems for the QR Sortie Lab
- Outfitting of the PI labs
- LPS equipment specifically for the QR activity.

In view of the facilities which will be available after completion of the Skylab and ASTP programs, it has been concluded that the QR activities use a portion of the existing O&C Building at KSC. The advantages of this choice are:

- Close proximity of the QR Sortie Lab work area to the local PI labs facilitating informal communications
- The QR Sortie Lab area will occupy only about 20% of the O&C high bay

An alternate is the Viking spacecraft building for the QR Sortie Lab work area. However, this building is not large enough to include the PI labs with the SL work area.

Figure 28 illustrates how the QR facilities could be incorporated into the O&C building.

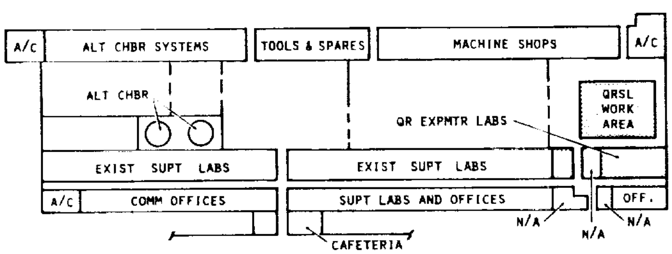


Figure 28.
QR Activities in O&C Building

Estimated Costs

The cost of modifying the portion of the O&C building recommended for the QR activities is estimated to be $725,000. This is broken down as follows:

QR SL Work Area	$250,000
PI Labs	$325,000
Environmental Qualification Lab	$150,000

The ground support equipment required to support this activity is estimated to cost $1.4 M. The major elements are:

QR Sortie Lab GSE (including test stand)	$450,000
Equipment for PI Labs	$250,000
Equipment for environmental qualification lab	$500,000
QR activity LPS equipment	$200,000

Organization and Manpower

Two basic approaches can be taken in developing an organization for the QR activity. These are:

1. A relatively autonomous QR organization using the basic institutional base support at the launch site.
2. An abbreviated QR organization, supplemented by launch site personnel from other non-QR Sortie Lab and Shuttle operations, and by basic institutional base support.

Based on the natural division of the WBS into R&D and operational functions and the goal of low cost operations, the second approach to the QR organization was selected. Figure 29 presents the abbreviated QR organization. The dedicated QR manpower is estimated to total 87, and includes management, engineers, technicians, and clerical personnel. The Mission Managers are shown as a staff function. They represent the QR integration activity to the PI and are his single point of contact (Figure 30). It is through the Mission Managers that the PI's requirements are transmitted.

The launch site Sortie Lab operations (non-QR) are shown on the left side in Figure 29. For servicing the non-QR Sortie Lab missions, approximately 74 people are required at 5 to

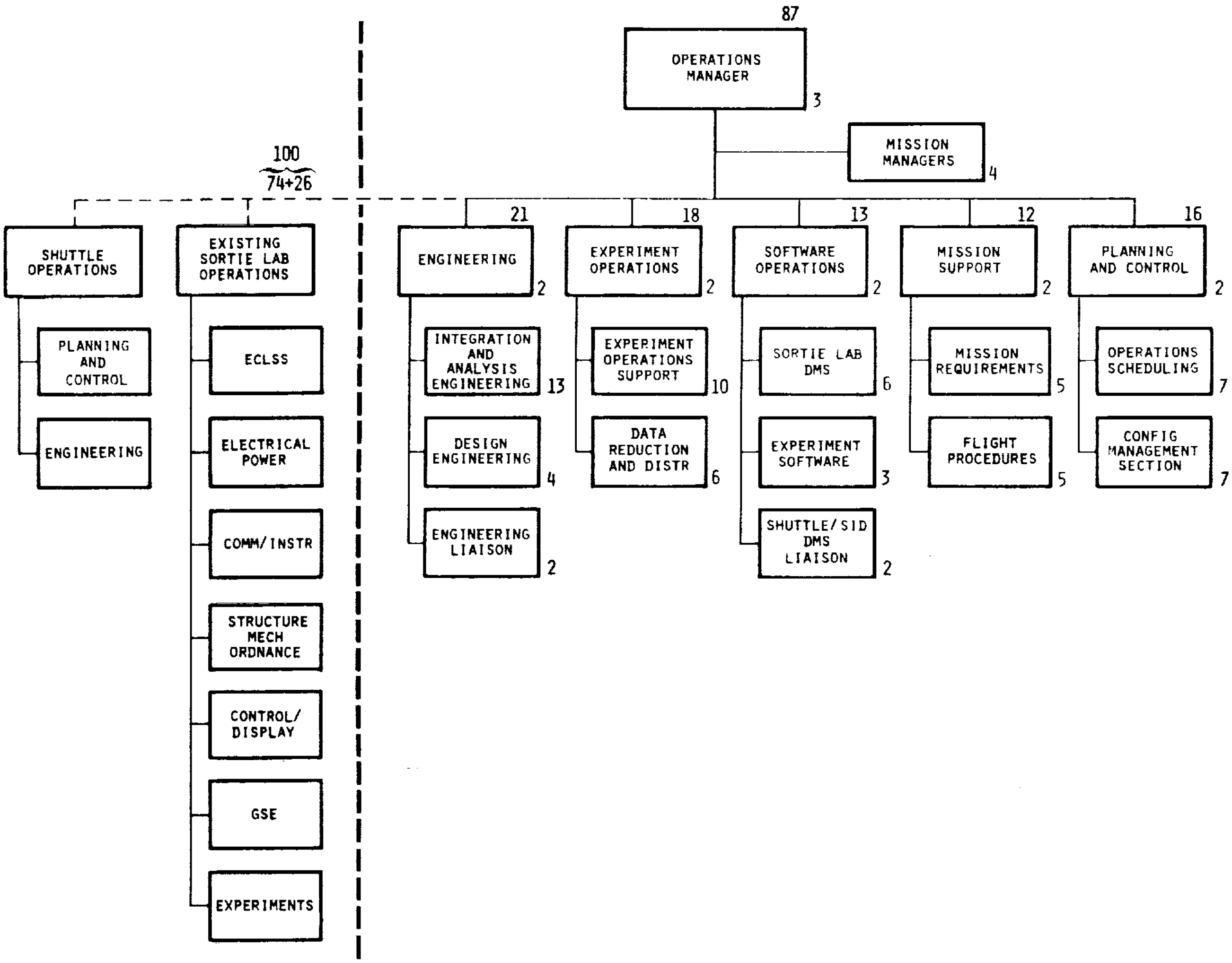


Figure 29. QRI Organization (Abbreviated)

9 SL flights/year. Augmenting this organization with approximately 26 people will handle the additional QR Sortie Lab missions. Thus, the total impact of the QR activity at the launch site is approximately 113 people (87 + 26).

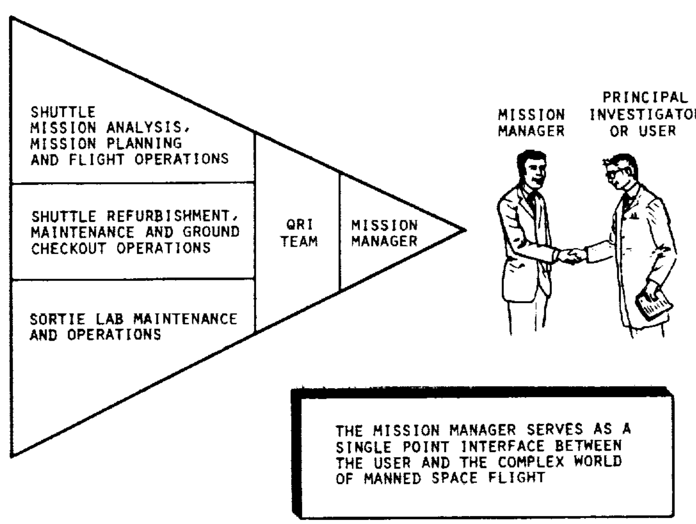


Figure 30.
Mission Manager Concept

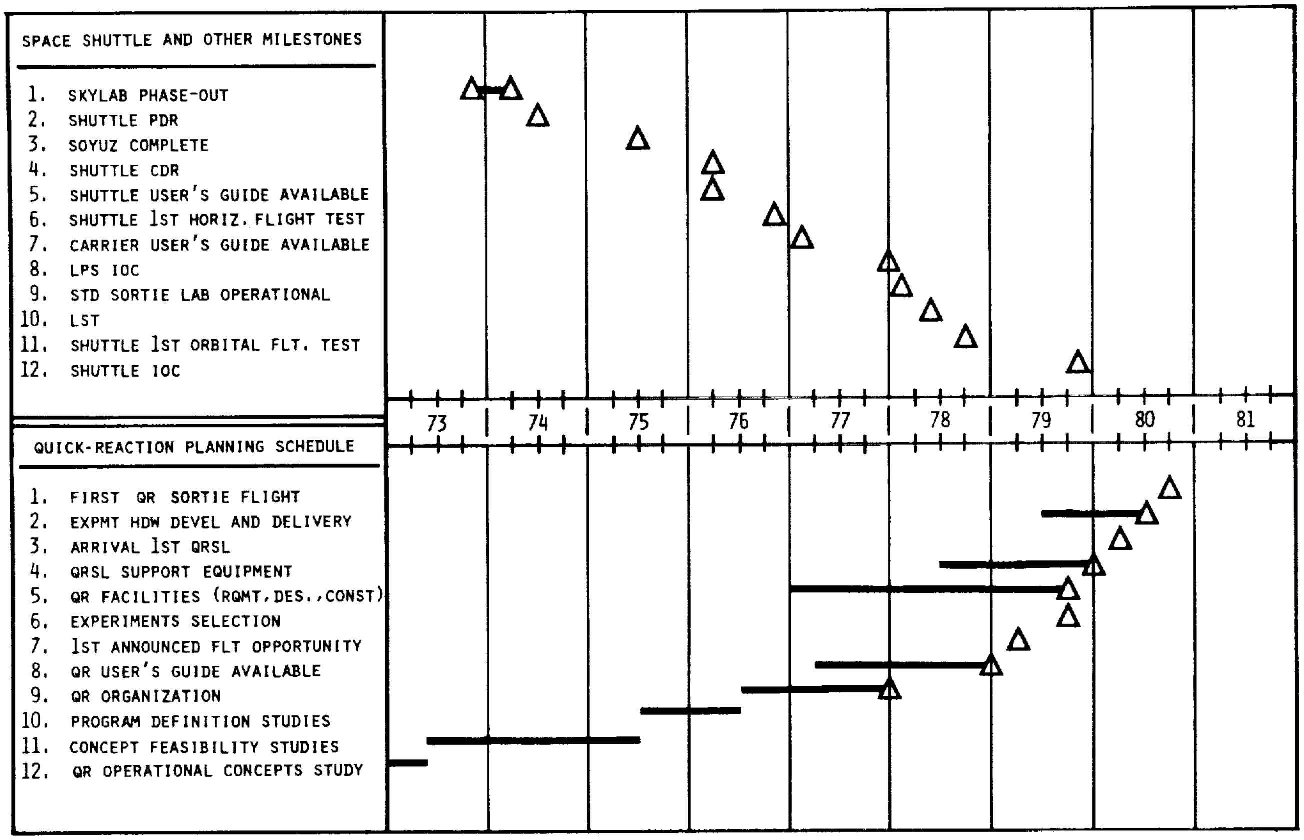


Figure 31. Planning Schedule

Implementation Planning Schedule

An implementation schedule developed for the QR program is shown in the lower half of Figure 31. This schedule is keyed to the external milestones shown in the upper half of the figure.

11.0 SENSITIVITY TO MISSION DENSITY

The sensitivity of the proposed baseline QR concept to changes in mission density was investigated. The baseline assumptions were:

- 4 QR flights/year
- 1 QR Sortie Lab
- Single shift operations

These additional assumptions were made to facilitate the sensitivity analysis:

- 2 operational Orbiters available
- 24 evenly spaced Shuttle launches/year
- 10 working day Orbiter ground turnaround time
- 7 calendar days from launch to landing
- No priority conflicts with other payloads.

A simplified ground operations baseline time flow is shown in Figure 32.

The analysis showed that up to 5 QR flights/year could be flown. A maximum of 7 QR flights/year is possible with two shift operations. At the other extreme, a reasonable continuity could be maintained with as few as 2 QR flights/year by stretching out the SL turnaround operations.

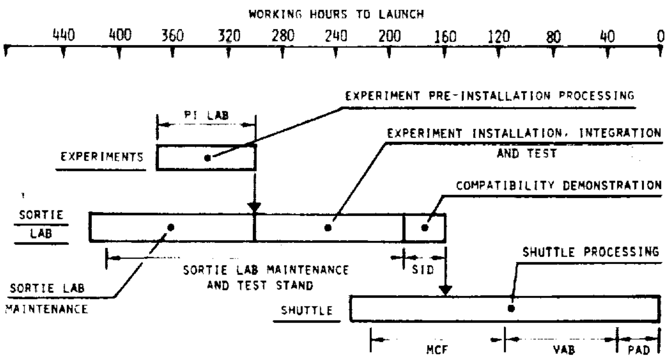


Figure 32.
QR Baseline Ground Operations Flow

The sensitivity of manpower requirements to changes in the mission density are shown in Figure 33 where:

- The SL M&O group is the launch site contingent for all SL's discussed earlier.
- The augmented SL M&O is the increase in the above group to allow the group to handle the QR Sortie Labs.
- The QRI team is the abbreviated organizational group, discussed earlier, dedicated to QRI operations.

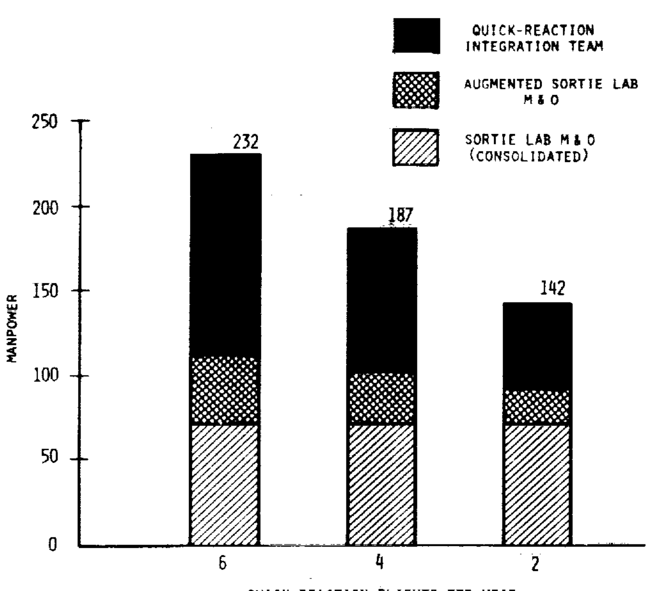


Figure 33.
Sensitivity Analysis Results

The launch site facilities/equipment requirements are insensitive to changes in mission density up to the point where two SL's are required. This occurs for 6 flights/year with single shift operations and 8 flights/year with double shift operations.

12.0 LOCATION/RESPONSIBILITY ALTERNATIVES ANALYSIS

The Baseline Concept developed in this study located all QRI activities at the Shuttle Launch Site, and assumed that the Shuttle Operator had functional responsibility for these activities. This means that either the QR operations reports to Shuttle operations or that both are in the same organization.

The objective of this analysis is to investigate the time and cost perturbations induced by performing the integration operations at a remote site (Alternate Concept A) or by the Sortie Lab Operator at the Launch Site (Alternate Concept B). In this case, the QR operator reports to a SL operator who is not under the Shuttle Operator. Consideration is also given to the possibility of multiple remote sites (Alternate Concept A1), each of which accomplishes the integration of experiments into a SL assigned to the particular site.

This approach to the analysis consists of developing scenarios depicting each of the Alternate Concepts as well as the Baseline, and comparing these concepts on the basis of these parameters:

<u>Performance</u>: The extent to which the concept meets user needs, desires and requirements and its compatibility with other on-going programs.

<u>Schedule</u>: The effectiveness of the concept in reducing normal payload processing time and contingency recycle time.

<u>Confidence Factors</u>: The orbiter turnaround and launch schedule impact risk inherent in the concept.

<u>Costs</u>: The efficiency of the concept in the use of facilities, equipment, and manpower. Transportation and documentation requirements associated with the concept are also evaluated.

The results of this analysis are summarized in Figure 34. Since remote sites were not specifically identified, complete comparisons could not be made for two of the parameters. The Baseline Concept and Alternate B were considered in depth, since each is located at KSC. This has probably resulted, unavoidably, in a more favorable comparison for these alternatives, and this factor should be considered in in any decisions based on this study.

The Baseline Concept is considered to best meet the established objectives, as defined by the parameters. A single location for both integration and launch processing has significant advantages in payload processing time, contingency recycle time, orbiter schedule impact risk, and transportation costs. The single

CONCEPT	BASELINE	A	A1	B
GEOGRAPHIC LOCATION	LAUNCH SITE	REMOTE SITE	MULTIPLE REMOTE SITE	LAUNCH SITE
FUNCTIONAL RESPONSIBILITY	SHUTTLE OPERATOR	SORTIE LAB OPERATOR	SORTIE LAB OPERATORS	SORTIE LAB OPERATOR
MEETS USER DESIRES, REQUIREMENTS, CONSTRAINTS	H	M	M	H
IS COMPATIBLE WITH ON-GOING PROGRAMS	M	-	-	M
MINIMUM PAYLOAD PROCESSING TIME	H	L	L	M
MINIMUM CONTINGENCY RECYCLE TIME	H	L	L	H
MINIMUM ORBITER SCHEDULE IMPACT RISK	H	L	L	H
MOST EFFECTIVE EQUIPMENT/FACILITY USE	H	M	L	H
MOST EFFECTIVE MANPOWER/SKILLS USE	H	-	-	M
MINIMUM DOCUMENTATION	H	L	L	M
MINIMUM TRANSPORTATION COST/TIME	H	L	L	H

Figure 34.
Comparison of Alternatives

organization of the Baseline Concept reduces organizational interfaces, hence, the paperwork associated with the transfer of responsibility and inter-organizational communication.

Alternate Concept B locates the integration activity at the launch site, but has all pre-installation activities under the functional responsibility of another organization - the SL Operator. This concept rates only slightly lower than the Baseline Concept, the difference being related to the inter-organizational interfaces and the resulting increase in formal paperwork and processing time. A small increase in manpower is also projected, since some duplication of effort historically occurs in this situation.

In Alternate Concept A, the integration of experiments is accomplished at a remote site and the completely integrated and tested SL is shipped to KSC for launch processing. This mode of operations is rated relatively low in the areas of payload processing time, contingency recycle time, orbiter schedule risk, and transportation costs. All of these factors are related to the remote geographical location. Documentation costs are also higher, since communications, transfer of responsibility, and logistics activities are more formal and of greater volume than at the co-located activities. In addition, facilities, equipment and manpower must be provided for maintenance and operation of the SL subsystems at the remote site, and this same capability will be required at the launch site. Unfortunately, since the remote site is not specifically designated, many potential advantages may be neglected in this analysis. For example, if the remote site is a Research or Development Center, considerable benefit may accrue from the use of trained personnel, laboratory facilities, and shops located at that Center.

In Concept A1, multiple remote sites are assigned QR Sortie Lab missions, and operate in the mode described for Concept A. Hence, the disadvantages noted for Concept A are multiplied by the number of remote sites. For QR missions, this appears to be the least desirable operational concept.

When NASA's overall plans develop to the point where the remote sites for QR payload integration can be specified, detailed site selection trade studies should be conducted. In the interim, the most practical mode of operation is desirable for planning purposes. This analysis concludes that the Baseline Concept describes the most practical mode of operation for QR missions.